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MOLASSES

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MOLASSES

Introduction

Molasses is probably the most important by-product of the sugar industry. It is also of interest from a chemical point of view and because of the variety of ways in which it has been utilized.

Molasses is the final mother sirup obtained in the crystallization of sugar. The manufacturing processes of the sugar industry may roughly be divided into two. The first is the purification of the juice obtained from the cane or beet, in which lime, carbon dioxide and sulfur dioxide are the principal reagents used, and the concentration to a sirup. The second is the fractional crystallization of the sirup or "thick juice" to obtain the sugar. In this vacuum pans and crystallizers are employed to produce crystals which are separated by means of centrifugals. The impurities, organic and inorganic, present in the juice (usually termed "non-sugars") prevent the crystallization of a certain part of the sugar; it is this final mother liquor which is molasses. It contains all the soluble impurities of the original juice, not removed in the process of purification, together with the sugar associated with them. The importance of molasses is seen when it is realized that from 15 to 25% of the sugar present in the original juice is found in the final molasses.

Distinction is sometimes made between a "true" molasses, which is a mother sirup from which no more sugar can be crystallized out under the most favorable conditions and a "commercial" molasses, which is obtained in manufacturing processes. Under efficient operating conditions, the two are practically the same. Low-grade cane molasses is often spoken of as blackstrap molasses.

Composition

The following analyses are average values for cane and beet molasses:

	Cane %	*Beet* %
Water	20	20
Sucrose	30	50
Raffinose	0	Present
Invert Sugar	32	Trace
Ash	6	10
Organic (non-sugar)	12	20
Sugar: non-sugar	3:5	5:3
Sugar: ash	5:1	5:1

The ash is interesting because of its high potash content and the very low soda content. Even in the presence of a large excess of soda salts in the soil, the sugar cane assimilates potash if available; and if not, it withers and dies. The potash content, which depends upon the nature of the soil, varies from 2 to 6%. During the war, because of the high cost of potash, serious attempt was made to recover this potash, and a plant was erected in California. The molasses was first fermented, the alcohol distilled, the yeast separated and the waste or slop evaporated to about 30° Be, and then burned in a reverberatory furnace. About 4 to 6% ash containing 36 to 38% potash was obtained, which was sold as such to the fertilizer industry. With the return to a normal price the process will probably not be a profitable one.

The non-sugar portion includes gum, organic acids (amino-acids) nitrogeneous bodies, caramel and other products of decomposition of the sugars. Betaine is isolated in considerable quantity and is used for medicinal purposes.

Uses

Sugar. Various processes have been developed through which the sugar present in the molasses may be recovered. These processes consist either in removing some of the impurities so as to increase the ratio of sugar to non-sugar present, or in precipitating the sugar as an insoluble compound, by the use of barium, strontium, or calcium oxide. These salts are then decomposed with carbon dioxide, when sugar and the corresponding carbonate are obtained. The barium process is in operation at Wallaceburg, Ontario, while the lime process (Steffen process) is used by the Great Western Sugar Co. The strontium process is used in Germany. Of the three processes the barium yields a product of the highest purity (93%) as compared with 88% for the strontium and 81% for the calcium process. On the other hand, the recovery of barium oxide from the carbonate involves an expensive electric furnace installation. In spite of the lower purity of the product from the calcium process, it would seem that this is the most satisfactory method for the ordinary factory.

Alcohol. One of the important uses of molasses is for the production of industrial alcohol. Formerly, it was also used for the manufacture of rum. Since the sugar is present in a fermentable form, it requires no preliminary treatment, such as is necessary in the case of grain and potatoes. The molasses is simply diluted to a suitable concentration (17 to 22%), acidified with sulfuric acid, inoculated with yeast, and allowed to stand at an initial temperature of 18°C. (65°F.) for 48 to 96 hours, when the fermentation is complete. The yield is about 3.75 gallons of 95% alcohol per 100 pounds of molasses, or about 75 gallons per ton.

The following tables give the amount of molasses consumed

during the past five years in the production of rum and cologne spirits:

RUM

	Molasses used Gallons	*Rum produced Gallons*
1910	2,900,376	2,253,624
1915	3,833,578	2,844,313
1916	3,943,301	2,908,898
1917	3,653,755	2,881,414
1918	1,860,361	1,526,743
1919	1,000,425	816,103

COLOGNE SPIRITS

	Molasses used Gallons	*Spirits produced Gallons*
1910	39,392,697	20,587,200
1915	*119,467,918	39,736,548
1916	77,034,173	58,052,924
1917	*108,843,878	82,460,340
1918	*116,167,599	83,293,277
1919	*122,498,268	75,407,357

*Includes dilute saccharine liquid.

At the present time the abnormal price of industrial (denatured) alcohol makes this a very attractive proposition.

Food. The impurities of the sugar cane have a pleasant aromatic flavor and raw cane sugar and cane sirups are common articles of human diet. Beet sugar molasses, while not suitable for human consumption, is used as a cattle food.

According to Deerr, the use of molasses as a cattle food originated with an observation by Hughes that the interior pith of the sugar cane was capable of absorbing large quantities of molasses, affording a product which could be shipped in bags; this was called " molascuit." Various other absorbents have been used, among which may be mentioned peat, sphagnum moss, bran and various kinds of meal, beet pulp and alfalfa. Molassine meal is composed of beet and cane molasses absorbed on sphagnum moss, while Xtravim feed contains cane molasses only. There are some fifty or more mixed feeds on the market, all of which contain more or less molasses. The amount of such feed produced each year is roughly estimated by " Sugar " at 2,000,000 tons; the molasses content varies from 10 to 50%.

Molasses as such is not a complete food, since it contains only about 0.15% nitrogen. Its food value lies in its sugar content. It is generally recognized that the salts of molasses have a distinct value in stimulating the appetite and the digestion, so that larger amounts of forage are eaten.

Typical analyses of molasses feeds follow:*

	Protein	*Fat*	*Fiber*
Sucrose	16.50	3.50	12.50
H. & S. Alfalfa	19.50	4.20	12.35
International Dairy	18.94	5.98	11.72
Purina	17.83	3.09	17.18
Cloverleaf Horse	9.58	1.89	12.05
Algrave Horse	11.64	4.56	9.78
Xtravim	5.24	0.50	4.95
Green Cross	9.50	2.25	7.19
Molassine Meal	8.82	0.63	6.25

*Selected at random from Control Series, Bulletin 3, Mass. Agr. Expt. Station, Amherst, Mass.

Use as Fuel. Molasses is occasionally used as fuel to supplement that afforded by bagasse. The simplest way is to let the molasses fall onto the bagasse on its way to the furnaces. It may also be atomized and burned in a special furnace. Actual determinations by Atwater have given a value of 6956 B.T.U. per pound of dry matter; or of 4500 B.T.U. when the 25% water content is not removed. Air dried wood gives from 4500 to 5000 B.T.U., bagasse with 45% water 4500 B.T.U., petroleum 16000-17000 B.T.U. and anthracite coal 15000-16000 B.T.U. per pound.

If the ashes are returned to the soil, most of the potash is made available as plant food.

Fertilizer. Many experiments have been carried out to determine the fertilizing value of molasses. The results thus far are conflicting. One set indicates that molasses aids the nitrogen-fixing organisms in their work, resulting in an increase in the nitrogen content of the soil and in increased crops. Another study has shown that the continued addition of glucose to soil bacteria *in vitro* retards the activity of the nitrifying and ammonifying organisms and accelerates that of the denitrifying races. The truth is still to be determined.

Other Uses. Blackstrap molasses is also used in the leather industry and in the preparation of shoe blacking and leather dressing.

Statistics

Statistics on the world production of molasses are very difficult to obtain. The following figures are taken from the July, 1920 issue of *Sugar*.

" The total amount of cane molasses produced in the United States during the season of 1918-1919 was 28,049,000 gallons, according to the United States Department of Agriculture, of which 16,101,650 gallons was blackstrap. The amount of beet molasses obtained from the manufacture of beet sugar is practically negligible, since the introduction of the Steffens process in beet sugar factories, and no figures are available for this product.

Practically all of that which is obtained, however, is used for feeding purposes.

" The only available figures for production in foreign countries are for Porto Rico during the season of 1918-1919 when 18,000,000 gallons were produced, practically all of which was blackstrap. It is estimated that about 22,000,000 gallons will be obtained from the present crop. The production of molasses in Cuba during 1918-1919 was estimated at 198,588,800 gallons, all of which may be regarded as blackstrap.

" Imports of molasses into the United States for 1918-1919 are as follows:

	Gallons
Cuba	124,254,663
Porto Rico	15,118,678
Hawaii	11,065,996
Other countries — (Central America, Mexico, Peru and other South American countries, Dominican Republic and Philippine Islands)	5,820,054"

Molasses Production[1]

United States

(Source: Stat. Abs. 1919, p. 231. All figures of molasses production prior to 1915-1916 are those of A. Bouchereau, New Orleans, except that for census years and 1898-1899, which are those of the Census Bureau. Subsequent figures are those of the Department of Agriculture.)

	Louisiana Gallons	*Other Southern States Gallons*	*Total Gallons*
1852-1860[2]	20,032,717	1,065,213	21,097,930
1861-1870[2]	8,048,261	951,954	9,000,215
1871-1880[2]	11,096,738	1,213,302	12,310,040
1881-1890[2]	14,737,034	3,800,728	18,537,762
1891-1895[2]	21,277,179	6,124,752	27,401,930
1896-1900[2]	20,661,216	6,431,452	27,092,662
1901-1905[2]	26,953,377	7,718,527	34,671,902
1906-1910[2]	24,982,244	6,264,496	31,246,748
1911-1915[2]	25,540,900	10,804,632	36,345,535
1915-1916	15,230,000	.....	.....
1916-1917	30,387,000	.....	.....
1917-1918	36,379,000	25,622,811	62,001,811
1918-1919	38,842,000	35,584,000	74,426,000
1919-1920	.....	.....	.....

[1] All figures for molasses, except those for 1898-99, include sirup; those for 1918-19 for "Other Southern States" relate to sirup only.

[2] Average for the period.

Molasses Production in Louisiana

(Source, Year Book of the Department of Agriculture, 1919.)

	Gallons	*Gallons per ton of Sugar*
1911	35,062,525	99
1912	14,302,169	93
1913	24,046,320	82
1914	17,177,143	71
1915	12,743,000	93
1916	26,154,000	86
1917	30,728,000	126
1918	28,049,000	100
1919	.....	.....

1911-1914 — Louisiana Sugar Planters' Association figures.
1914-date — Bureau of Crop Estimates, U. S. Dept. Agr.

Exports (United States)

	Gallons	*Value*
1910	1,505,355	$216,336
1915	1,148,741	145,274
1916	4,387,369	524,861
1917	2,889,991	442,967
1918	3,811,341	847,692
1919	6,123,765	1,277,980

Imports (United States)

	Gallons	*Value*
1910	31,292,165	$1,367,362
1915	70,839,623	1,963,505
1916	85,716,673	3,775,894
1917	110,237,888	10,946,571
1918	130,730,861	9,177,833
1919	130,074,717	7,471,060

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ABBREVIATIONS

Agr. News	Agricultural News.
Am. Sugar Ind.	American Sugar Industry.
Amer. Vet. Rev.	American Veterinary Review, The.
Ann.	Annalen der Chemie.
Ann. agron.	Annales Agronomiques.
Ann. chim. anal.	Annales de chimie analytique et revue de chimie analytique.
Ann. fals.	Annales des falsifications.
Ann. sci. agron.	Annales de la science agronomique.
Apoth.-Zeit.	Apotheker-Zeitung.
Arb. deut. Landw-Gesell.	Arbeiten der deutschen Landwirtschafts-Gesellschaft.
Arch. far. sper.	Archivio di farmacologia sperimentale e scienze affini.
Arch. ges. Physiol.	Archiv für die gesamte Physiologie des Menschen und der Tiere.
Arch. Suikerind.	Archief voor de Suikerindustrie in Nederlandsch-Indie.
Arch. voor de Java Suikerindustrie	Archief voor de Java Suikerindustrie.
Beet Sugar Gaz.	Beet Sugar Gazette, The.
Ber.	Berichte der deutschen chemischen Gesellschaft.
Ber. Agr. Chem. Kontroll. u. Vers. Stat. Pflanzenkrank. Prov. Sachsen	Berichte über die Tätigkeit der Agrikulturchemischen Kontrollstation und der Versuchsstation für Pflanzenkrankheiten der Landwirtschaftkammer für die Provinz Sachsen.
Ber. K. Vet. og Landbohöjskoles Lab. Landökonom. Forsög	Beretning fra den Kongelig Veterinaer- og Landbohöjskoles Laboratorium for Landökonomiske Forsög.
Ber. physiol. Lab. u. Vers. Anst. Landw. Inst. Halle	Berichte aus dem physiologischen Laboratorium und der Versuchsanstalt des Landwirthschaftlichen Instituts der Universität Halle.
Biedermanns Zentr.	Biedermanns Zentralblatt für Agrikulture Chemie und rationellen Landwirtschaftsbetrieb.
Bl. Zuckerrübenbau	Blätter für Zuckerrübenbau.
Bol. Inst. Agron. Sao Paulo	Boletim do Instituto Agronomico do Estado de Sao Paulo em Campinas.
Bull. assoc. chim. sucr. dist.	Bulletin de l'association des chimistes de sucrerie et de distillerie.

Bull. de la soc. des chim. de Maurice	Bulletin de la société des chimistes de Maurice.
Bull. agr. Algérie et Tunisie	Bulletin agricole de l'Algérie et de la Tunisie.
Bull. assoc. belge des chim.	Bulletin de l'association belge des chimistes.
Bull. Bur. Chem.	Bulletin of the Bureau of Chemistry.
Bull. soc. chim.	Bulletin de la société chimique de France.
Bull. soc. chim. de belg.	Bulletin de la société chimique de belgique.
C. A.	Chemical Abstracts.
Centr. Bakt. Parasitenk.	Centralblatt für Bakteriologie, Parasitenkunde und Infectionskrankheiten.
Centr. Kunstdungerind.	Centralblatt Kunstdungerindustrie.
Centr. Zuckerind.	Centralblatt für die Zuckerindustrie.
Chem. Zentr.	Chemisches Zentralblatt.
Chem. Weekblad	Chemisch Weekblad.
Chem.-Ztg.	Chemiker-Zeitung.
Cir. hebd. Fabr. Sucre France	Circulaire hebdomadaire du Syndicat des Fabricants de Sucre de France.
Compt. rend.	Comptes rendus hebdomadaires des séances de l'académie des sciences.
Compt. rend. acad. agr. France	Comptes rendus des seances d'academie d'agriculture de France.
Dept. Landb. Nijv. en Handel	Department van Landbouw, Nijverheid en Handel.
Deut. Essigind.	Deutsche Essigindustrie.
Deut. landw. Presse	Deutsche landwirtschaftliche Presse.
Deut. Zuckerind.	Deutsche Zuckerindustrie.
Dingler's polytech. J.	Dingler's polytechnisches Journal.
E. S. R.	Experiment Station Record.
Illust. landw. Ztg.	Illustrierte landwirtschaftliche Zeitung.
Imp. Dept. Agr. West Indies	Imperial Department of Agriculture for the West Indies.
Inaug. Diss.,Univ.Berne	Inaugural Dissertation. University of Berne.
Ind. Merc.	De Indische Mercuur.
Industrie chimique	Industrie chimique, L'Revue universell des produits chimiques des industries annexes.
Ingén. agr. Gembloux	L'Ingénieur agricole de Gembloux.
Intern. Sugar J.	International Sugar Journal, The,
J. agr. prat.	Journal d'agriculture pratique et journal de l'agriculture.

J. Am. Chem. Soc.	Journal of the American Chemical Society.
J. Assoc. Official Agr. Chemists	Journal of the Association of Official Agricultural Chemists.
J. Bd. Agr.	Journal of the Board of Agriculture.
J. Econ. Entomol.	Journal of Economic Entomology.
J. fabr. sucre	Journal des fabricants de sucre.
J. Franklin Inst.	Journal of the Franklin Institute.
J. Hyg.	Journal of Hygiene.
J. Ind. Eng. Chem.	Journal of Industrial and Engineering Chemistry.
J. Roy. Agr. Soc.	Journal of the Royal Agricultural Society of England.
J. Roy. Soc. Arts	Journal of the Royal Society of Arts.
J. S. C. I.	Journal of the Society of Chemical Industry.
Jahresber. landw. Vers. Stat. Jersitz bei Posen	Jahresbericht landwirtschaftliche Versuchsstation, Jersitz bei Posen.
K. Landtbruks-Akad. Handl. Tid.	Kungl. Landtbruks-Akademiens Handlingar och Tidskrift.
Lab. Inland Rev. Dept.	Laboratory of the Inland Revenue Department, Canada.
Landtm. Manadsbl.	Landtmannens Manadsblad.
Landw. Jahrb.	Landwirtschaftliche Jahrbücher (Zeitschrift für wissenschaftliche Landwirtschaft.)
Landw. Vers.- Sta.	Landwirtschaftlichen Versuche-Stationen, Die.
Landw. Wochbl. Schles.-Holst.	Landwirthschaftliches Wochenblatt für Schleswig-Holstein.
Landw. Ztg.	Landwirtschaftliche Zeitung (Führlings).
Landw. Z. Rheinprovinz	Landwirthschaftliche Zeitschrift für die Rheinprovinz.
La. Planter	Louisiana Planter and Sugar Manufacturer, The.
Meded. Proefstat. Java Suikerind.	Mededeelingen van het Proefstation voor de Java-Suikerindustrie.
Meded. Proefstat. Suikerriet West-Java	Mededeelingen van het Proefstation voor Suikerriet in West-Java.
Meddel. Centralanst. Försoksv. Jordbruksomradet	Meddelande fran Centralanstalten för Försöksvasendet pa Jordbruksomradet.
Met. Chem. Eng.	(Metallurgical and Chemical Engineering.)
Milch Ztg.	Milch Zeitung.

Mitt. chem.-tech. Vers. Stat. Centr. Rubenz.-Indus. Oesterr.-Ungar	Mitteilungen der chemische-technischen Versuchsstation des Centralvereins für Rübenzucker-Industrie in der Oesterr.-Ungar Monarchie.
Mon. sci.	Moniteur scientifique du Docteur Quesneville.
Neue Z. Zuckerind.	Neue Zeitschrift für Zuckerindustrie.
Nord. Mejeri Tidn.	Nordisk-Mejeri-Tidning.
N. Dak. Sta. Spec. Bull.	North Dakota Station Special Bulletin.
Oesterr.-ung. Z. Zuckerind.	Oesterreichisch-ungarische Zeitschrift für Zuckerindustrie und Landwirtschaft.
Oesterr.-ung. Brennereizeit.	Oesterreichisch-ungarische Brennereizeitschrift.
Orig. Com. 8th Intern. Cong. Appl. Chem.	Original Communication, 8th International Congress of Applied Chemistry.
Philippine J. Sci.	Philippine Journal of Science, The.
Proc. A. O. A. C.	Proceedings of the Association of Official Agricultural Chemists.
Prog. agr. vit.	Progress agricole et viticole.
Rend. soc. chim. ital.	Rendiconti della societa chimica italiana.
Rev. chim. ind.	Revue de chimie industrielle.
Rev. gén. chim.	Revue générale de chimie pure et appliquée.
Rev. ind. agr. Tucumán	Revista industrial y agricola de Tucumán.
Rev. prod. chim.	Revue des produits chimiques, La.
Rpt. Ann. Sta. Agron., Mauritius	Report Station Agronomique, Colony of Mauritius.
School of Mines Quart.	School of Mines Quarterly.
Sci. Am.	Scientific American.
Sta. Agron. Mauritius, Bull.	Station de la Agronomique, Mauritius, Bulletin.
Staz. sper. agrar. ital.	Stazioni sperimentali agrarie italiane, Le.
Sucr. ind. colon.	Sucrerie indigene et coloniale.
Tidskr. Landtmän	Tidskrift för Landtmän.
Ugeskr. Landm.	Ugeskrift for Landmaend.
Verslag Ver. Exploit. Proefzuivelboerdij Hoorn.	Vereeniging tot Exploitatie eener Proefzuivelboerderij to Hoorn, Verslag.
Vie agri. et rurale	Vie agricole et rurale, La.
Westnik Sacch. Prom.	Westnik Sakharnoi Promyshlennosti.
Wiener landw. Ztg.	Wiener landwirtschaftliche Zeitung.
Württemb. Wochbl.	Württembergisches Wochenblatt für

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Landw.	Landwirthschaft.
Z. anal. Chem.	Zeitschrift für analytische Chemie.
Z. angew. Chem.	Zeitschrift für angewandte Chemie.
Z. Elektrochem.	Zeitschrift für Elektrochemie.
Z. landw. Versuchsw.	Zeitschrift für das landwirtschaftliche Versuchswesen in Oesterreich.
Z. Nahr. Genussm.	Zeitschrift für Untersuchung der Nahrungs- und Genussmittel, sowie Gebrauchsgegenstände.
Z. öffent. Chem.	Zeitschrift öffentliche Chemie.
Z. Spiritusind.	Zeitschrift für Spiritusindustrie.
Z. Ver. Rübenzuckerind.	Zeitschrift des Vereins für Rübenzucker-Industrie.
Z. Ver. Zuckerind.	Zeitschrift des Vereins der deutschen Zuckerindustrie.
Z. Zuckerind. Böhmen	Zeitschrift für Zuckerindustrie in Böhmen.
Zentr. Agr. Chem.	Zentralblatt Agrikulturchemie.

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